WATER QUALITY MONITORING IN AUSTRIA

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Abstract

New legislation and administrative procedures regarding water pollution control in Austria form the basis for a new country-wide water quality monitoring system for running waters. This water quality assessment is used to discuss general principles and features of water quality monitoring systems (design of the monitoring network, choice of variables, aspects of sampling, data management, etc.). Furthermore, results of the first investigation period are presented.

Chovanec, A.: **Wassergüte - Monitoring in Österreich**

Neue wasserrechtliche Gegebenheiten in Österreich stellen seit 1990 die Voraussetzung für die Schaffung eines flächendeckenden Wassergüte-Monitorings für Fließgewässer dar. Anhand dieses wichtigen wasserwirtschaftlichen Instrumentes werden wesentliche Grundlagen derartiger Monitoring-Systeme diskutiert (Errichtung des Meßstellennetzes, Auswahl der Parameter, Probenahme, Verwaltung der Daten u.s.w.). Darüber hinaus werden exemplarisch Ergebnisse der ersten Untersuchungsperiode präsentiert.

Chovanec, A.: **Monitorování kvality vody v Rakousku**

Nový zákon a administrativní postupy týkající se kontroly znečištění vody jsou podkladem pro nové celostátně rozšířené monitorování kvality vody toků v Rakousku. Výsledky hodnocení kvality vody jsou použity ke stanovení hlavních principů monitorovacích programů (plánu monitorovací sítě, výběru parametrů, odběrového režimu, vyhodnocení dat, atd.). Článek uvádí předběžné výsledky tohoto výzkumu.

GENERAL REMARKS ON 'MONITORING'

Monitoring is currently fashionable within water quality assessment (e.g. UMWELTBUNDESAMT BERLIN, 1990; KRONVANG et al., 1993). In view of the many varieties of water pollution management, it is first necessary to define the term monitoring and to briefly describe different forms of monitoring. In the broadest sense monitoring designates all those activities that are aimed at obtaining information on water quality. However, this should exclude taking single samples at a selected point to check compliance with a standard (WARD et al., 1990). A first restriction with regard to the scope of the concept of monitoring is to talk about controlled and systematized information.

MEYBECK et al. (1992a) distinguish between different water quality assessment processes based on data collection:

Monitoring: long-term, standardized measurement, observation, evaluation and reporting on the aquatic environment in order to define its status and trends.

Survey: finite duration, intensive programme to measure, evaluate and report on the quality of the aquatic environment for a specific purpose.

Surveillance: continuous, specific measurement, observation and reporting for the purpose of water quality management and operational activities.

According to the major focus of water quality assessment MEYBECK et al. (1992 a,b) define different types of assessment:

Basic monitoring: analysis of physical/chemical/biological standard variables.

Impact monitoring: intensive chemical analysis adapted to the specific problems of a watercourse.

Trend monitoring: charting the long-term evolution of pollution.

Background monitoring: background levels for studying natural processes, used as a reference for pollution and impact assessments.

Others: basic survey (identification and location of major survey problems and their spatial distribution); preliminary survey (inventory of pollutants), emergency survey (rapid inventory and analysis of pollutants, rapid situation assessment following a catastrophic event), impact survey (sampling limited in time and space, generally focusing on few variables, near pollution sources); modelling survey (limited in time and space and the choice of variables, eutrophication models or oxygen balance models); early warning surveillance (at critical water use locations, continuous and sensitive measurements); operational surveillance (provides local and regional planning and environmental management authorities with data for such purposes as checking compliance with criteria and the efficiency of water and environmental protection measures; characterized by a high station density in a restricted area).

These types of assessment differ in many points, such as station density and location, sampling frequency, number of variables, duration, and interpretation lag. On the other hand they interact in many ways: preliminary surveys are often suited for determining the necessity and the technical and financial feasibility of a monitoring programme. Data obtained from background monitoring help to interpret the results obtained from trend or impact monitoring. Hydrological monitoring (including for example water discharge measurements) should be related to the water quality data and is indispensable in estimating pollution loads.

Primarily, monitoring seems to be characterized by an appropriate duration which is longer than that of surveys. As GOLDSMITH (1991) puts it: "...survey was what we have all been doing for years; it is

an inventory; it is static in its background philosophy and it is usually done once only. On the other hand monitoring is purpose orientated; it tells how something(s) is/are changing;...thus it is dynamic in philosophy..."

NIVA (1987) notes: "... the term 'monitoring' will be defined as obtaining a series of periodic measurements of selected determinants over time, with the purpose of defining time changes or trends in the determinants and in the system to which they relate. Thus, monitoring programmes are intended to describe the temporal variability of environmental system components, as contrasted to surveys that are conducted to establish spatial variance within a given system of time."

Another approach to the various forms of monitoring is taken by WARD et al. (1990). Monitoring can be categorized according to the following points:

Types of measurements to be made: physical/chemical monitoring (e.g. toxic substance monitoring, nutrient monitoring); biological monitoring (e.g. indicator species, community studies, bioassays and toxicity tests).
Location of water in the hydrological cycle: e.g. river monitoring, lake monitoring, groundwater monitoring, acid rain monitoring, effluent monitoring.
Type of water quality management tool to be supported. Monitoring may also be categorized in terms of the utilization of the monitoring results within management, e.g. compliance monitoring, enforcement monitoring, trend monitoring, background monitoring.
Length of projected life of the monitoring system.

Finally, the definitory approach of MASON (1989) should be mentioned. Surveys only provide information on the situation at one point in time, e.g. measurements of specific substances in a river downstream of the output of a factory's effluent. Surveillance signifies the repeated measurement of variables in order to detect trends. If measures of water pollution management such as setting quality standards are taken into account, especially to improve the condition of the river receiving the effluents, the term monitoring has to be used. This approach contradicts the general idea of establishing, for example, background monitoring programmes.

To summarize, the key elements of monitoring programmes are an appropriate duration, standardized data collection and transfer, as well as the flow of information through a series of components of the respective monitoring system. Further limits are set by the different objectives and strategies of monitoring programmes.

THE AUSTRIAN WATER QUALITY MONITORING PROGRAMME

Basically, the monitoring system covers both running water and ground water. The main features are: the monitoring system provides up-to-date and detailed information on river and ground water quality; changes in the water quality are indicated very quickly; the main areas of water pollution can be detected and remediation measures carried out effectively; the progress of remediation measures can be supervised by monitoring (Fig. 1).
The most important steps of the system are depicted in a flow digram (Fig. 2).

Description of the flow diagram

Effective water pollution control depends on an appopriate **legislative and administrative framework**. The establishment of the monitoring programme is laid down in the Ordinance on Water Quality Monitoring ("Wassergüte-Erhebungsverordnung",

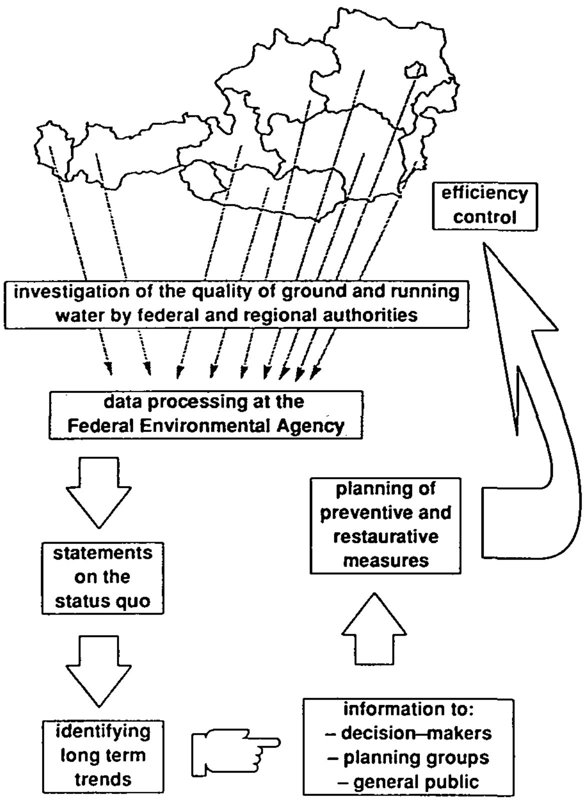


Fig. 1

Water Quality Monitoring System in Austria

THE STRUCTURE OF THE AUSTRIAN WATER QUALITY MONITORING SYSTEM

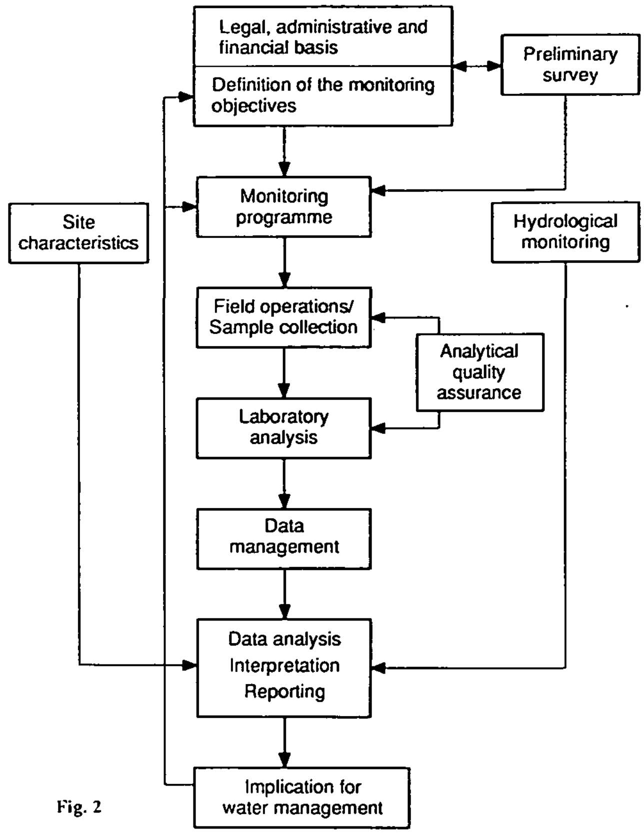


Fig. 2

"WGEV", 1991) which was issued as a result of the large-scale redrafting of the water law in Austria. This is primarily reflected in the amendment of the Austrian Federal Act on Water Law and of the Federal Act on Hydrography.

The requirements of the water quality monitoring programme led to a co-operation (established by two agreements of the ministers involved) between the Federal Ministry for Agriculture and Forestry represented by the Dept. of the Federal Water Management Register (FWMR) and the Federal Ministry for the Environment, Youth and Family Affairs represented by the Federal Environmental Agency (FEA). Both bodies work closely together in organizing the country-wide running water and ground water quality monitoring and the enforcement of the laws mentioned above as well as that of the Federal Environmental Control Act.

The **costs** of analyses and data transfer are met by federal (2/3) and provincial (1/3) authorities; the costs of establishing sampling sites are met totally by federal authorities. A preliminary survey was carried out as a joint project of the FWMR and the FEA (GRATH et al., 1992). Detailed information on the legal and administrative background is given in WASSERWIRTSCHAFTSKATASTER / UMWELTBUNDESAMT (1993).The following descriptions are concerned solely with the running water monitoring programme. For information on ground water monitoring see SCHIMON et al. (1993) and WASSERWIRTSCHAFTSKATASTER / UMWELTBUNDESAMT (1993).

The **objectives** of the monitoring system can be summarized as follows: compared to previous surveys, the data collected provide more detailed and standardized information on the status of running water quality as well as on the identification of

long-term trends. In water management these factors represent important information for decision makers, planning groups, and the general public, and form the basis for protective and restorative measures and their efficiency control provided in the Federal Act on Water Law. According to the categorizations discussed in the first chapter of this paper the Austrian monitoring system primarily integrates elements of impact, trend, and compliance river monitoring.

The results presented in the present paper comprise the samplings at 150 **sites** which are given in Fig. 3: The main catchment areas as laid down in the Federal Law on Hydrography are indicated by numbers as follows.
1: Rhine; 2: Danube upstream the Inn; 3: from Inn to Salzach; 4: Salzach; 5: Inn downstream the Salzach; 6: Danube from Inn to Traun; 7: Traun; 8: Enns; 9: Danube from Traun to Kamp (excluding Enns); 10: Danube from Kamp to Leitha (excluding March), Moldau; 11: March; 12: Leitha; 13: Rabnitz and Raab; 14: Mur; 15: Drau.
The final extension of the monitoring network to 250 sampling sites was carried out in the autumn of 1993.

The **investigation programme** of the monitoring system comprises analyses of water, sediments, and biota ("WGEV", 1991). Water samples are collected six times a year (every two months), while sediment samples and biological material are colected once a year. At some sampling sites, water samples are taken twelve times a year because of special bilateral agreements on transboundary water management issues. At each sampling site about 50 variables are measured: they comprise basic variables like pH, conductivity, Biochemical Oxygen Demand (BOD), Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), nutrients, etc., as well as variables which - up until now - at best were the subject of specific surveys such as

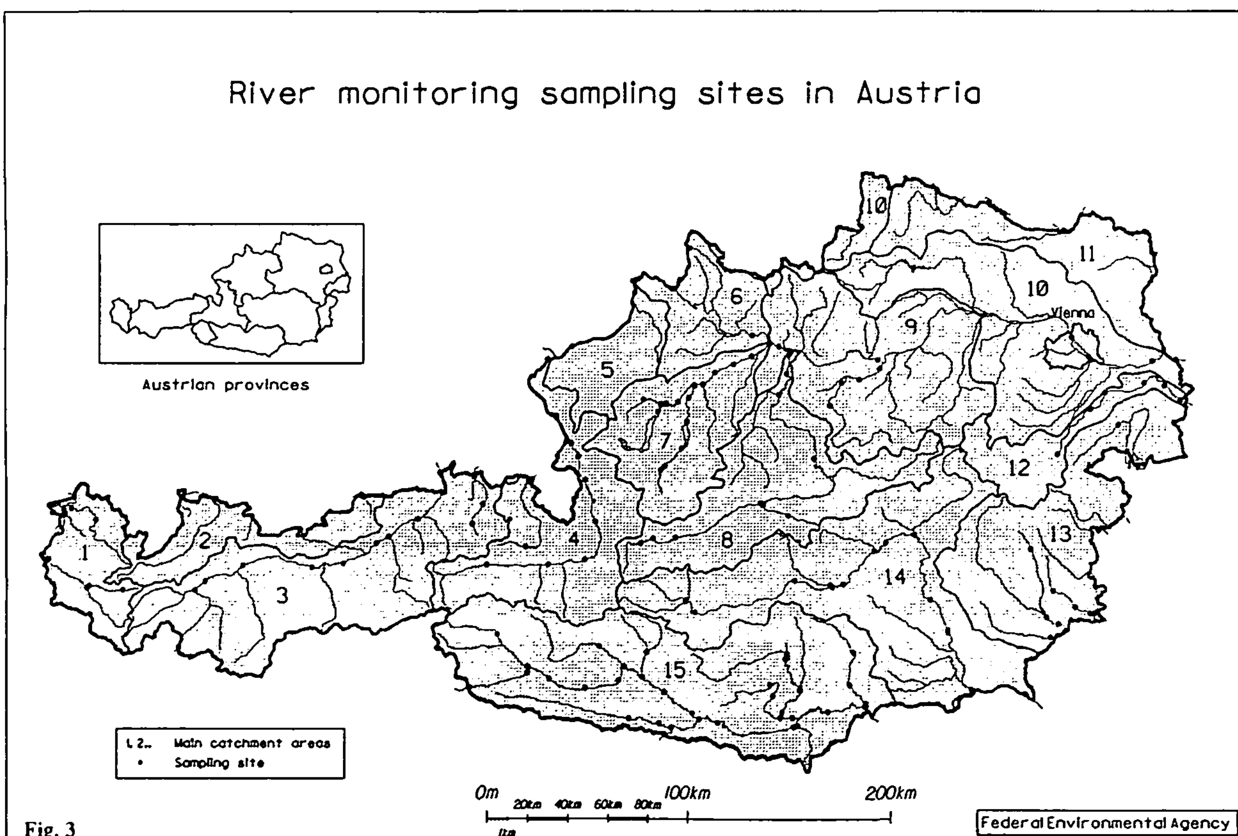


Fig. 3

Adsorbable Organic Halogens (AOX), pesticides, and Polycyclic Aromatic Hydrocarbons (PAH) (e.g. VOGEL & CHOVANEC, 1992; CHOVANEC et al., 1993a). The **continuous adaptation** of the monitoring programme to specific requirements of water pollution control combined with an appropriate selection of the variables is organized within a six year investigation cycle of initial (two years) and recurring follow-up measurements (four years). After finishing the cycle a new one starting with intitial measurements has to be begun (SCHIMON, 1991; "WGEV", 1991).

In order to guarantee the smooth running of the system, annually updated manuals (e.g. GRATH et al., 1991) are prepared to promote the standardization of the following monitoring practices on a country-wide scale: coding of the variables by numbers, sample numbering, sampling protocols, forms for sample site description, field measurements, sample transport and transfer as well as data transfer. This is vital to achieve compatibility of information from the different participants of the programme.

The **flow of the data** (Fig. 4) runs as follows: laboratories - provincial authorities - FWMR - FEA.
Data transfer from the provincial authorities to the federal authorities is carried out by sending disks. At the FEA data are handled by a mainframe, personal computers, and geographic information systems. The corresponding software packages as well as the PC-software for the provincial authorities have been developed by the Federal Environmental Agency (e.g. SCHICHO-SCHREIER et al., 1991; NAGY, 1993; WASSERWIRTSCHAFTSKATASTER / UMWELTBUNDESAMT, 1993).

Every year a **call for tenders** is organized by the provincial authorities to select the

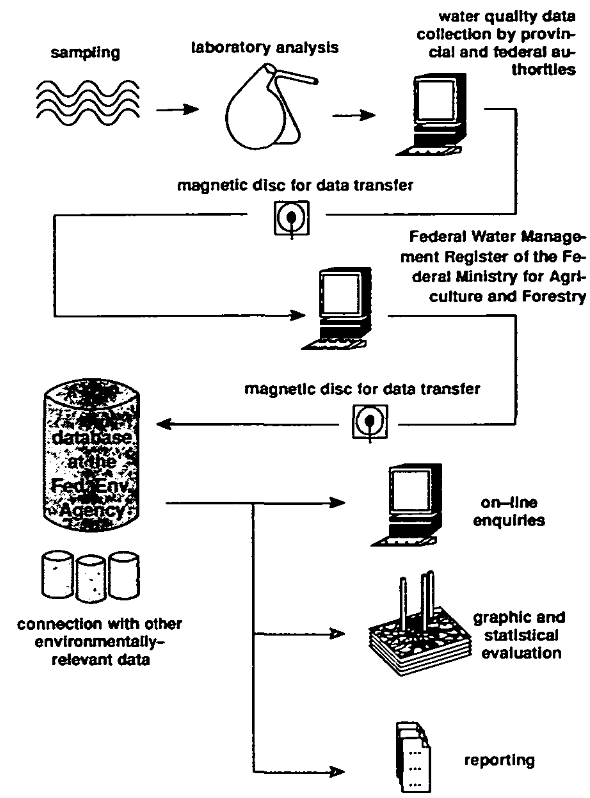


Fig. 4 Graphic: Fed. Env. Agency

Data Flow of the Austrian Water Quality Monitoring System

laboratories which carry out the sample collections and chemical analyses of the programme (SCHWAIGER et al., 1992). The FWMR and the FEA are leading institutions in **promoting quality assurance procedures** in water quality analysis methods as well as data management. The manuals standardizing relevant procedures also serve for quality assurance from bottle washing to data entry. The software, for example, provides the possibility to evaluate the balance of ions, which is one element of data verification procedures. Other examples are the infiltration of double samples into the analytical procedures, laboratory comparison tests (e.g. SCHMID & SÖVEGJARTO, 1991), and laboratory control visits.

An **annual report** is published by the FWMR in close co-operation with the FEA (CHOVANEC & WINKLER, 1993). The data are also subjected to detailed specific evaluations (CHOVANEC et al., 1993b). The

first results aggregated for the main catchment areas were published in CHOVANEC et al. (1993c). The information obtained about the site characteristics (e.g. local effluents, degree of channelization, damming) and data obtained from hydrological monitoring (water discharge) are key elements for the interpretation (e.g. for the evaluation of pollution loads).

The monitoring system will probably be an important element of the **Austrian water management** since it will allow assessment of compliance of the monitoring data with **quality standards**. At present, Austria's water management lacks obligatory surface water quality standards; there is only a draft ordinance on running water pollution which sets different standards for rivers of mountainous and lowland regions (HEFLER, 1992).

The results presented in the reports and papers will, in turn, influence the definition of the objectives of the monitoring programme in the future: pointing out regional and country-wide pollution problems will have an influence on the selection of the variables and on the promotion of specific surveys carried out to evaluate detailed pollution problems, e.g. self purification capacity, importance of diffuse pollution sources. Thus, last but not least, the monitoring system will give an important impulse to scientific water quality assessment in Austria.

METHODS

The methods of the analytical procedures are laid down in the Ordinance on Water Quality Monitoring ("WGEV", 1991).

DOC: ÖNORM M 6284, 01.88
DIN 38409-Teil 3, 06.83
sample filtered through a 0.45 µm membranous filter
BOD: ÖNORM M 6277, 02.91
DIN 38409-Teil 51, 05.87
Ammonium: ÖNORM ISO 7150-Teil 2
S1, 12.87
AOX: ÖNORM M 6275, 11.87
DIN 38409-Teil 14, 03.85
Atrazine: "Rückstandsmethoden, Teil 1, 2. Auflage, April 1989" of the Biologische Bundesanstalt für Land- und Forstwirtschaft Braunschweig, Germany.

RESULTS AND DISCUSSION

Detailed results of the data collected at 150 sampling sites within the first investigation period (Dec. 1991 - Dec. 1992) are presented in CHOVANEC & WINKLER (1993, 1994). First results aggregated for the main catchment areas as laid down in the Federal Law on Hydrography were published in CHOVANEC et al. (1993c).

The results of the first investigation period (Dec. 1991 - Dec. 1992) presented in this paper are evaluated for each sampling site by median and maximum value (for DOC) as well as in an aggregated form for the 15 main catchment areas (for BOD-5 days, NH_4-N, AOX, Atrazine). Table 1 lists the numbers of the collected values in the different catchment areas for the variables presented.

The evaluation of the DOC (Fig. 5 a, b, c) data for the individual sampling sites reveals sites in several parts of the country where the proposed limit values of the draft ordinance (lowland rivers: 5.5 mg/l; mountainous rivers: 2.5 mg/l) are exceeded by the maximum values. In the north and east of Austria there are also sampling sites where even the median is higher than the future limit value for lowland rivers. The peak values (between 10 and 16 mg/l) were measured in the rivers Pöls and Strem, and in the Vienna "Donaukanal", the receiving water body of the effluents of the Vienna waste water treatment plant. In catchment

Catchment area	DOC	BOD	NH4-N	AOX	Atrazine
01	12/ 72	12/ 72	12/ 72	12/ 72	0/ 0
02	0/ 0	1/ 1	1/ 1	0/ 0	1/ 1
03	13/ 57	14/ 61	14/ 61	13/ 55	14/ 61
04	13/ 73	14/ 87	14/ 88	14/ 59	14/ 88
05	0/ 0	3/ 10	3/ 10	2/ 2	2/ 5
06	2/ 12	2/ 24	2/ 24	2/ 4	2/ 21
07	17/ 85	17/ 85	17/ 85	17/ 85	17/ 85
08	11/ 44	11/ 44	11/ 44	11/ 44	11/ 44
09	6/ 28	6/ 40	6/ 40	6/ 20	6/ 37
10	4/ 24	4/ 46	4/ 46	4/ 9	4/ 44
11	5/ 13	5/ 32	5/ 32	1/ 2	5/ 28
12	6/ 26	6/ 30	6/ 30	6/ 23	6/ 30
13	8/ 42	8/ 51	8/ 51	6/ 31	8/ 51
14	13/ 43	13/ 43	13/ 43	13/ 43	13/ 42
15	34/ 162	34/ 163	34/ 164	34/ 164	34/ 164
Total	**144/ 681**	**150/ 789**	**150/ 791**	**141/ 613**	**137/ 701**

Table 1: Number of sampling sites in each catchment area / number of data collected during the investigation period for different parameters.

area 11 (March), 58 per cent of the values collected are higher than 5.5 mg/l. The interpretation of the BOD, NH_4-N, AOX and atrazine is taken from CHOVANEC & WINKLER (1994). The BOD results (Fig. 6a) aggregated for the catchment areas clearly indicate serious pollution in the north and east of Austria, especially in the catchment areas 10 (Danube from Kamp to Leitha, excluding March; Moldau) and 11 (March; values of up to 12 mg/l); 53 per cent of the values exceed the proposed limit value for lowland rivers of 6.0 mg/l (the corresponding value for mountainous rivers is 3.5 mg/l).

Analyses of the ammonium-data (Fig. 6b) confirm the state of rivers in the north and east of Austria (maximum value of the River March: 3.1 mg/l); additionally high concentrations were recorded in catchment area 1 (Rhine) in the west of the country. The limit values of the draft ordinance are 0.5 mg/l for lowland rivers and 0.3 mg/l for mountainous rivers, respectively. In the Vienna "Donaukanal" mentioned above, values of 68 mg/l BOD and 21.7 mg/l NH_4-N were measured.

The analysis of AOX (Fig. 7a) is a suitable means of evaluating waste water effluents of pulp and paper industries, which are a major source of water pollution in Austria (e.g. VOGEL & CHOVANEC, 1989; KROISS, 1993). First monitoring results for the AOX aggregated for the catchment areas are published in CHOVANEC et al. 1993b,c). The AOX concentrations are particularly noteworthy in the catchment area of the River Mur (no.14). This region is strongly influenced by the effluents of pulp and paper plants. Nearly 50 per cent of the values measured in this region were above 50 µg/l, the future limit value for

Fig. 5a

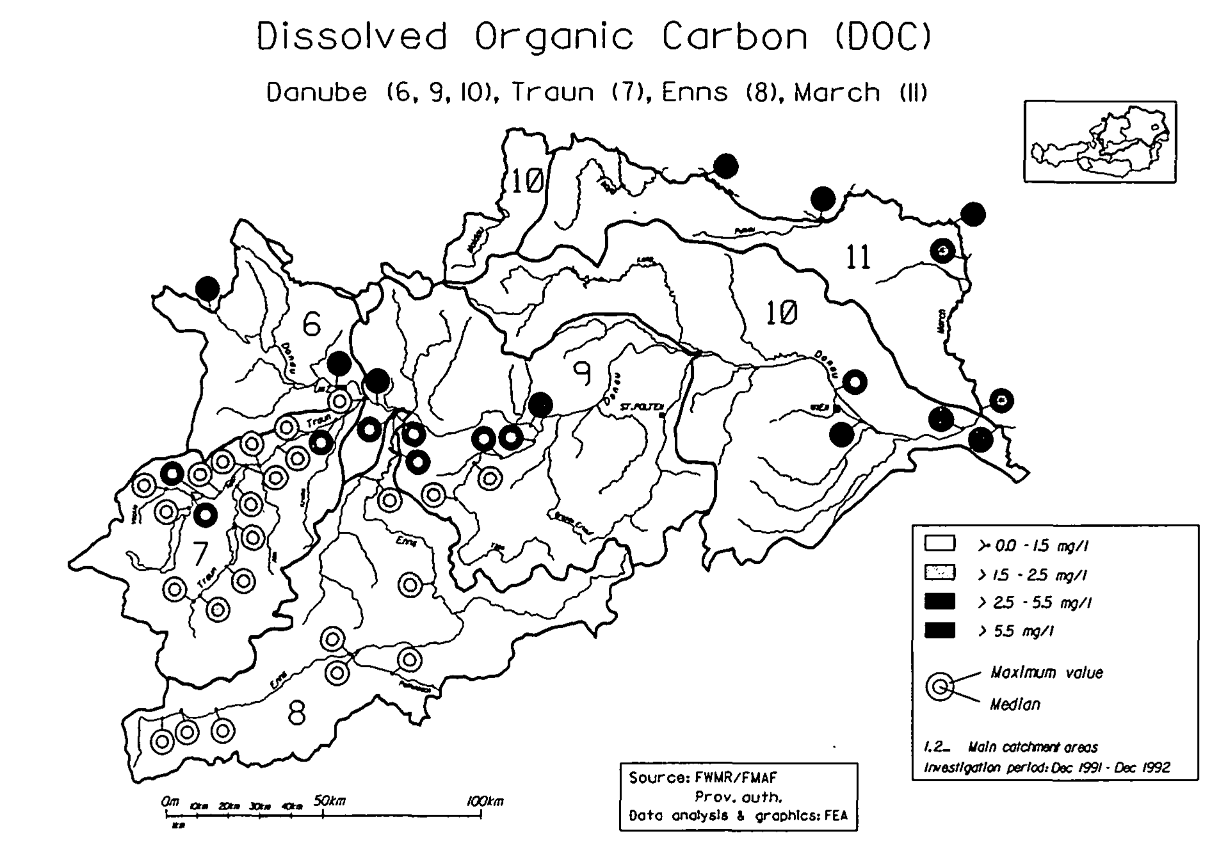

Dissolved Organic Carbon (DOC)
Danube (6, 9, 10), Traun (7), Enns (8), March (11)
10
11
10
6
9
7
8
ST. PÖLTEN
WIEN
> 0.0 - 1.5 mg/l
> 1.5 - 2.5 mg/l
> 2.5 - 5.5 mg/l
> 5.5 mg/l
Maximum value
Median
1, 2_ Main catchment areas
Investigation period: Dec 1991 - Dec 1992
Source: FWMR/FMAF
Prov. auth.
Data analysis & graphics: FEA
0m
50km
100km

Fig. 5b

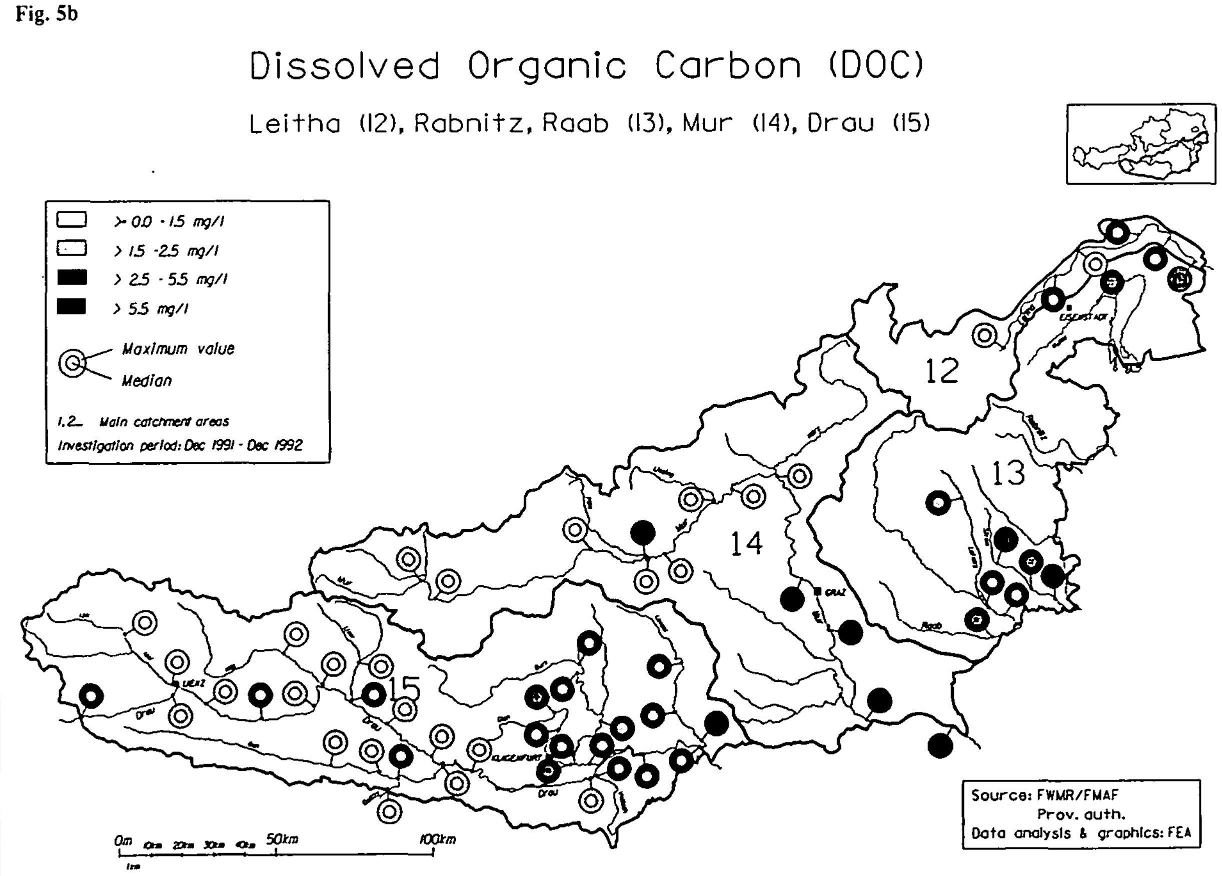
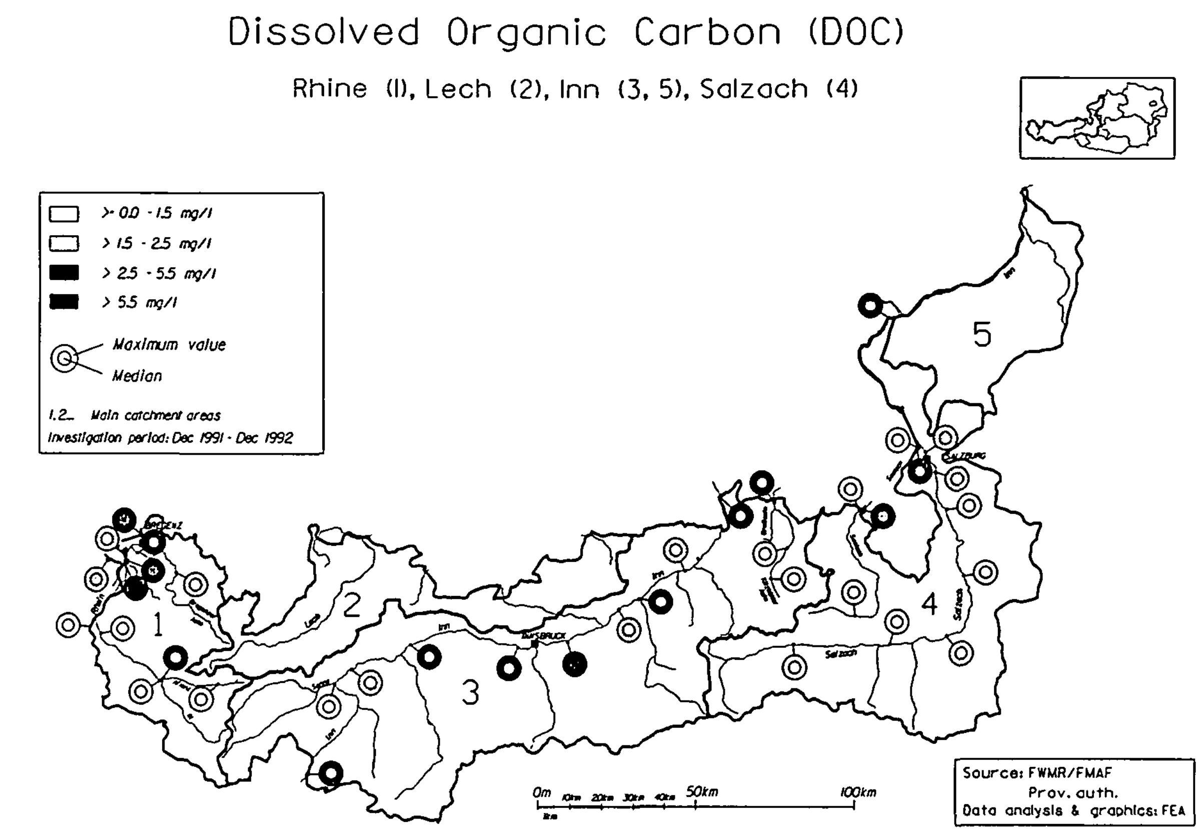

Dissolved Organic Carbon (DOC)
Leitha (12), Rabnitz, Raab (13), Mur (14), Drau (15)
> 0.0 - 1.5 mg/l
> 1.5 - 2.5 mg/l
> 2.5 - 5.5 mg/l
> 5.5 mg/l
Maximum value
Median
1, 2_ Main catchment areas
Investigation period: Dec 1991 - Dec 1992
12
13
14
15
GRAZ
Raab
Drau
Source: FWMR/FMAF
Prov. auth.
Data analysis & graphics: FEA
0m
50km
100km

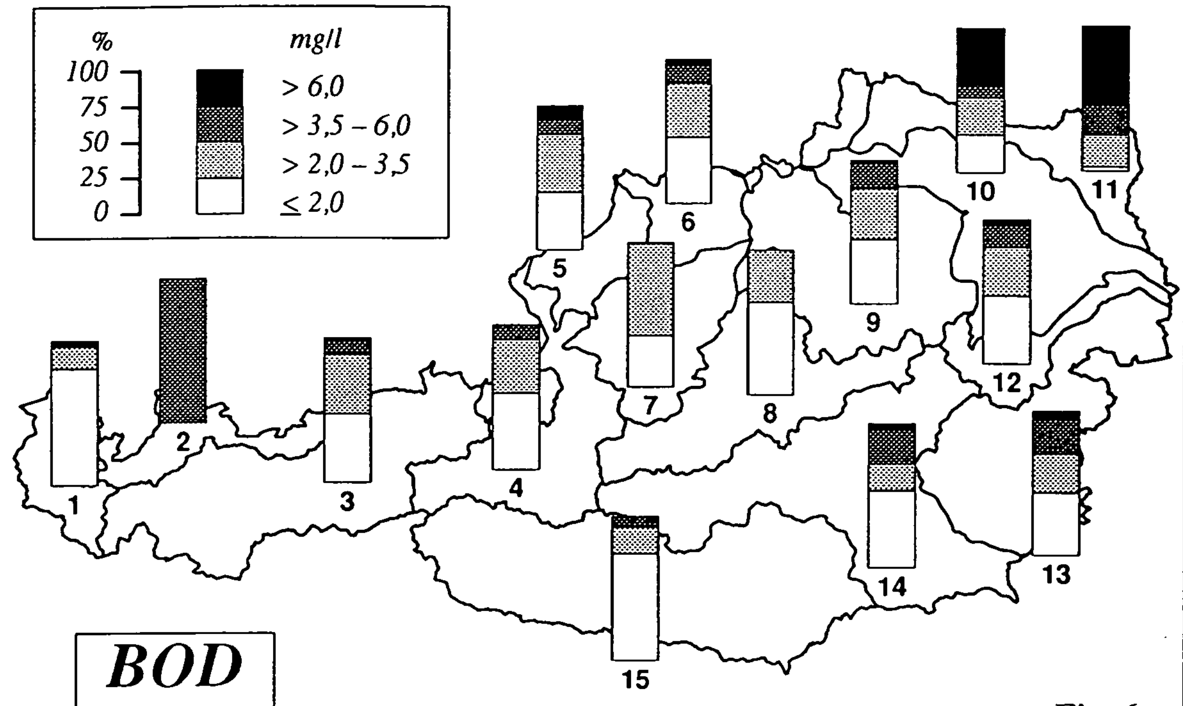
Fig. 5c



both lowland and mountain river types. Peak concentrations were found in the small triver Pöls, resulting from a pulp mill using chlorine or chlorine derivatives for bleaching (maximum value 2,300 µg/l).
The River Pöls, which is also characterized by high BOD concentrations, even affects the River Mur (maximum value 550 µg/l). The impacts of other pulp and paper mills in Austria on aquatic ecosystems could be reduced in the last years: some plants apply effective waste water treatment processes, other sites have been closed. The low AOX concentrations found throughout the country (74% of all values were between 0 and 10 µg/l) are probably due to the use of household chemicals.

The regions in Austria with intensive agriculture are characterized by high atrazine concentrations (Fig. 7b; maximum value: 3.5 µg/l; limit value set by the ordinance: 0.1 µg/l). The concentrations measured in the River Danube indicate an imported atrazine load.

Since the different sampling sites were only gradually incorporated into the monitoring network, and because of the higher sampling frequencies at the sampling sites which are subject to bilateral agreements, the sampling frequencies are not yet uniform. Most of the stations (77) were sampled five times within the first investigation period. The evaluations are not corrected for various specific properties that may affect the rivers. The results, therefore, only show general trends in the national distributions of pollutant concentrations (CHOVANEC & WINKLER, 1994).


%
100
75
50
25
0
mg/l
> 6,0
> 3,5 – 6,0
> 2,0 – 3,5
≤ 2,0
1
2
3
4
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8
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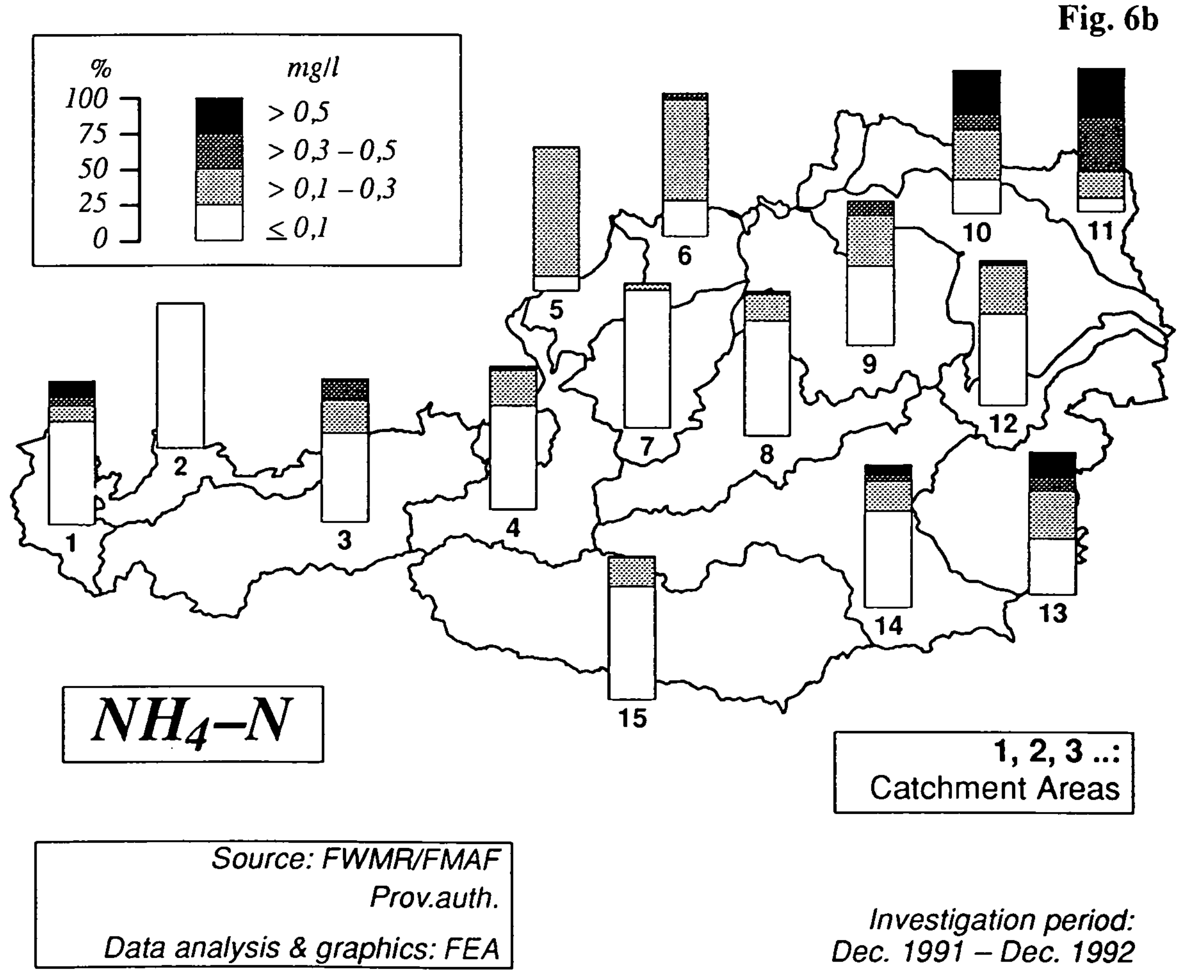
11
12
13
14
15
BOD

Fig. 6a

Fig. 6b


%
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mg/l
> 0,5
> 0,3 – 0,5
> 0,1 – 0,3
≤ 0,1
1
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7
8
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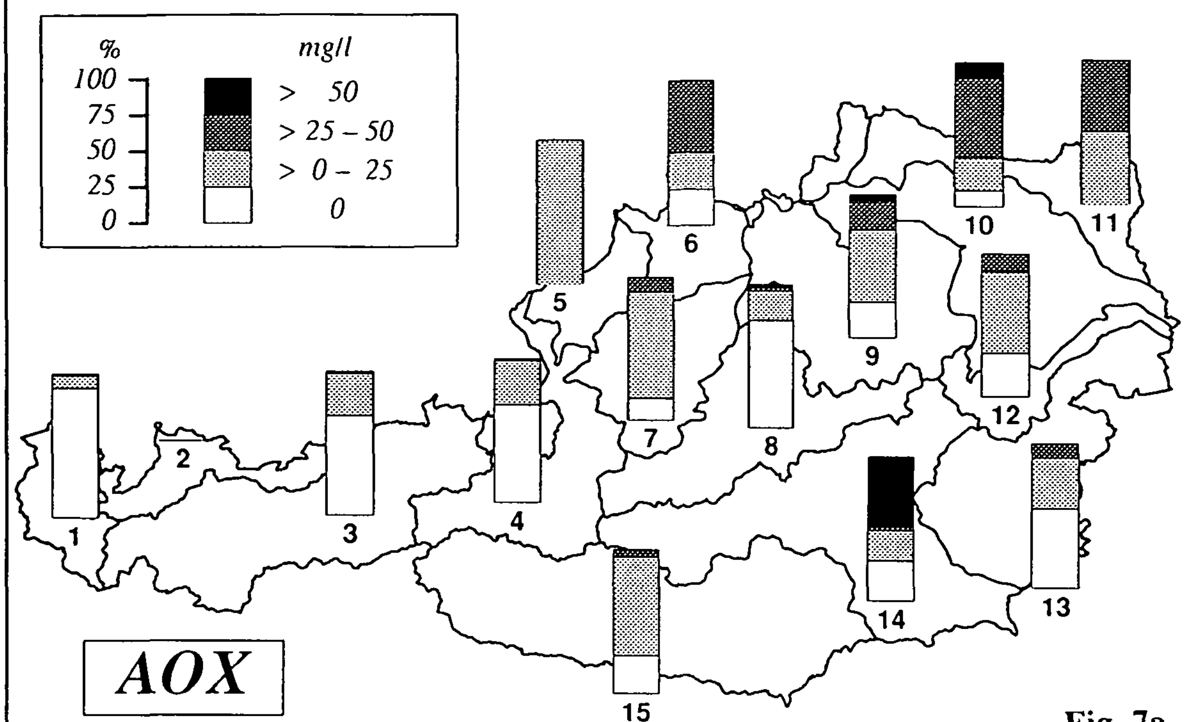
15
NH4–N
1, 2, 3 ..:
Catchment Areas
Source: FWMR/FMAF
Prov.auth.
Data analysis & graphics: FEA
Investigation period:
Dec. 1991 – Dec. 1992



%
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> 25 – 50
> 0 – 25
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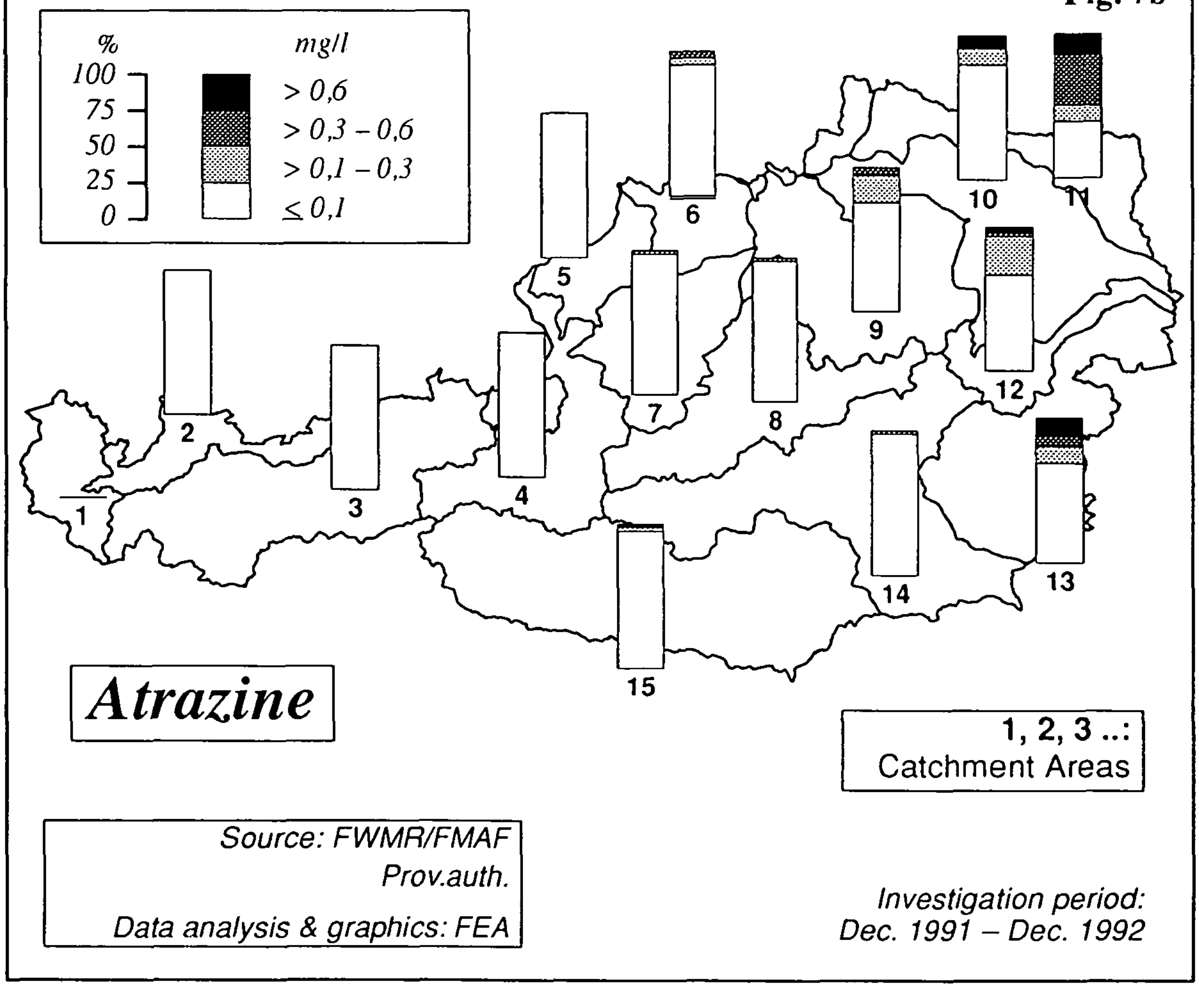
15
AOX

Fig. 7a

Fig. 7b



%
mg/l
100
75
50
25
0
> 0,6
> 0,3 – 0,6
> 0,1 – 0,3
≤ 0,1
1
2
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4
5
6
7
8
9
10
11
12
13
14
15
Atrazine
1, 2, 3 ..:
Catchment Areas
Source: FWMR/FMAF
Prov.auth.
Data analysis & graphics: FEA
Investigation period:
Dec. 1991 – Dec. 1992

The evaluations of the first investigation period provide a first overview of the water quality of Austria's running waters obtained by a nationwide, systematized, and standardized programme. The extension of the network from 150 to 250 sampling sites will allow more detailed interpretations. It is planned to enforce investigations on the importance of waste water effluents at local and regional levels, as well as the impact of different forms of land use on running waters, thus rendering detailed interpretation of individual pollution sources possible. For this reason, detailed descriptions of the sampling sites are necessary. Further interpretations have to include data on water discharge for the evaluation of pollution loads (CHOVANEC & WINKLER, 1994).

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